Ecological Assessment of Streams in the Coal Mining Region of West Virginia Using Data Collected by the U.S. EPA and Environmental Consulting Firms

Interim Results
April 11, 2002

Assessment Objectives

Currently, there are three major reports generated from the U.S. EPA Region 3's collection of ecological data in the MTM/VF Region of West Virginia (i.e., Green et al., 2000 Draft; U.S. EPA Region 3, 2001 Draft; and Stauffer and Ferreri, 2000); separate reports for macroinvertebrates, fish, and water chemistry data, respectively. The primary analysis in these reports is descriptive in nature. In addition, mining companies have collected an extensive amount of biomonitoring data that could also be incorporated in the EIS analysis. An integrated analysis of maining company and Region 3 data would increase the sample size for the EIS and potentially provide more information regarding the relationships among water chemistry, fish, macroinvertebrates and EIS classes. There are two primary objectives of the integrated assessment. The first of these objectives is to perform an analysis of the data collected by Region 3 and the data collected by mining company consultants, BMI, REIC and POTESTA. Results will be presented in a single report. The analysis will include two components: 1) a statistical evaluation of the EIS classes for fish and for macroinvertebrates, and 2) a statistical evaluation of the potential additive effects along the main stems of two watersheds for fish and macroinvertebrates. A second objective is an examination of chemical and physical habitat factors that may contribute to any potential differences among EIS classes detected for fish and invertebrates. Insights gained from the second objective may provide information to develop guidance to "minimize, to the maximum extent practicable, the adverse environmental effects to the waters of the United States and to fish and wildlife resources from mountaintop mining operations, and to environmental resources that could be affected by the size and location of fill material in valley fill sites".

Assessment Watersheds and Sites

Sites from six watersheds are included in the assessment: Mud River, Spruce Fork, Clear Fork, Twentymile Creek, Island Creek, and Twelvepole Creek. Each of these watersheds are within the MTM/VF Region of West Virginia. Two of the watersheds, Island Creek and Twentymile Creek, have both Region 3 and mining company sites where data were collected. One watershed, Twelvepole Creek, has only mining company data and three watersheds, Mud River, Spruce Fork and Clear Fork, have only Region 3 data. Tables 1 to 6 show the distribution of sites across EIS classes in each of the watersheds and the entity that provided the data. These sites represent a combination of water chemistry, habitat, fish and macroinvertebrate data. Some sites have a full set of indicator data collected (fish, macroinvertebrates, water chemistry, and habitat), whereas other sites only have a subset of indicator data. The least amount of data available is for habitat. Sampling occurred seasonally beginning in Spring of 1999 and ending in Winter 2001. Not all sites were sampled in each season. Only two watersheds provide sufficient data for the additive analysis, Twentymile Creek and Twelvepole Creek.

Table 1. Sites sampled in the Mud River Watershed.

Site ID/Organization	Stream Name	EIS Class
U.S. EPA Region 3		
MT01	Mud River	Mined/Residential
MT02	Rushpatch Branch	Unmined
MT03	Lukey Fork	Unmined
MT13	Spring Branch	Unmined
MT14	Ballard Fork	Filled
MT15	Stanley Fork	Filled
MT24	Unnamed Trib. to Stanley Fork	Sediment Control Structure
MT18	Sugartree Branch	Filled
MT23	Mud River	Filled/Residential
MT106	Unnamed Trib. to Sugartree Branch	Mined

Table 2. Sites sampled in the Spruce Fork Watershed.

Site ID/Organization	Stream Name	EIS Class
U.S. EPA Region 3		
MT39	White Oak Branch	Unmined
MT40	Spruce Fork	Filled/Residential
MT42	Oldhouse Branch	Unmined
MT45	Pigeonroost Branch	Mined
MT32	Beech Creek	Filled
MT34B	Left Fork	Filled
MT48	Spruce Fork	Filled/Residential
MT25B	Rockhouse Creek	Filled

Table 3. Sites sampled in the Clear Fork Watershed.

Site ID/Organization	Stream Name	EIS Class
U.S. EPA Region 3		
MT79	Davis Fork	Mined
MT78	Raines Fork	Mined
MT81	Sycamore Creek	Mined
MT75	Toney Fork	Filled/Residential
MT70	Toney Fork	Filled/Residential
MT69	Ewing Fork	Mined/Residential
MT64	Buffalo Fork	Filled
MT62	Toney Fork	Filled/Residential

Table 4. Sites sampled in the Twentymile Creek Watershed. Equivalent sites are noted parenthetically.

Site ID/Organization	Stream Name	EIS Class
U.S. EPA Region 3		
MT95 (=Neil-5)	Neil Branch	Unmined
MT91	Rader Fork	Unmined
MT87 (=Rader-4)	Neff Fork	Filled
MT86 (=Rader-7)	Rader Fork	Filled
MT103	Hughes Fork	Filled
MT98	Hughes Fork	Filled
MT104	Hughes Fork	Filled
BMI Sites		
Rader 8	Twentymile Creek	Additive
Rader 9	Twentymile Creek	Additive
PMC-TMC-36	Twentymile Creek	Additive
PMC-TMC-35	Twentymile Creek	Additive
PMC-TMC-34	Twentymile Creek	Additive
PMC-TMC-33	Twentymile Creek	Additive
PMC-TMC-31	Twentymile Creek	Additive
PMC-TMC-30	Twentymile Creek	Additive
PMC-TMC-29	Twentymile Creek	Additive
PMC-TMC-28	Twentymile Creek	Additive
PMC-TMC-27	Twentymile Creek	Additive
PMC-TMC-26	Twentymile Creek	Additive
PMC-7	Twentymile Creek	Additive
PMC-6	Twentymile Creek	Additive
PMC-5	Twentymile Creek	Additive
PMC-TMC-4	Twentymile Creek	Additive
PMC-TMC-5	Twentymile Creek	Additive
PMC-TMC-314	Twentymile Creek	Additive
PMC-TMC-2	Twentymile Creek	Additive
PMC-TMC-1	Twentymile Creek	Additive

Continued

Table 4 (Continued).

Site ID/Organization	Stream Name	EIS Class
BMI Sites		
PMC-HWB-1	Twentymile Creek	Additive
PMC-HWB-2	Twentymile Creek	Additive
Neil-6 (=Fola 48)	Twentymile Creek	Additive
Neil-7 (=Fola 49)	Twentymile Creek	Additive
Neil-2 (=Fola 53)	Neil Branch	Unmined
Neil-5 (=MT95)	Neil Branch	Unmined
Rader-1	Laurel Run	Unmined
Rader-2	Rader Fork	Unmined
Rader-3	Trib. to Rader	Unmined
Rader-4 (=MT87)	Neff Fork	Filled (2)
Rader-5	Neff Fork	Filled (2)
Rader-6	Trib. to Neff	Filled (1)
Rader-7 (=MT86)	Rader Fork	Filled (2)
PMC-1	Sugarcamp Branch	Filled (1)
PMC-11	Right Fork	Filled (1)
PMC-12	Road Fork	Filled (1)
PMC-15	Tributary to Robinson Fork.	Filled (1)
POTESTA Sites		
Fola 33	Twentymile Creek	Additive
Fola 36	Twentymile Creek	Additive
Fola 37	Twentymile Creek	Additive
Fola 38	Twentymile Creek	Additive
Fola 48 (=Neil-6)	Twentymile Creek	Additive
Fola 49 (=Neil-7)	Twentymile Creek	Additive
Fola 39	Peachorchard Branch	Filled (2 small)
Fola 40	Peachorchard Branch	Filled (1 small)
Fola 45	Peachorchard Branch	Unmined
Fola 53 (=Neil-2)	Neil Branch	Unmined

Table 5. Sites sampled in the Island Creek Watershed.

Site	Stream Name	EIS Class
U.S. EPA Region 3		
MT50	Cabin Branch	Unmined
MT51	Cabin Branch	Unmined
MT107	Left Fork	Unmined
MT52	Cow Creek	Filled
MT57B	Hall Fork	Filled
MT57	Hall Fork	Filled
MT60	Left Fork	Filled
MT55	Cow Creek	Filled/Residential
BMI Sites		
Mingo 34		Filled (1)
Mingo 41		Filled (2)
Mingo 39		Filled (1) + old mining
Mingo 16		Unmined
Mingo 11		Unmined
Mingo 2		Unmined
Mingo 86		Unmined
Mingo 62		Unmined
Mingo 38	Island Creek	Additive
Mingo 24	Island Creek	Additive
Mingo 23	Island Creek	Additive

Table 6. Sites sampled in the Twelvepole Creek Watershed. Equivalent sites are noted parenthetically.

Site ID/Organization	Stream Name	EIS Class
REIC Sites		
BM-001A	Twelvepole Creek	Additive
BM-001C	Twelvepole Creek	Additive
BM-001B	Twelvepole Creek	Additive
BM-001	Twelvepole Creek	Additive
BM-010	Twelvepole Creek	Additive
BM-011	Twelvepole Creek	Additive
BM-002	Twelvepole Creek	Additive
BM-002A	Twelvepole Creek	Additive
BM-003A	Kiah Creek	Additive
BM-003	Kiah Creek	Additive
BM-004	Kiah Creek	Additive
BM-004A	Kiah Creek	Additive
BM-005	Trough Fork	Additive
BM-006	Trough Fork	Additive
BM-UMC	Milam Creek	Unmined
BM-DMC	Milam Creek	Unmined
BM-DBLC	Laurel Creek	Unmined
BM-UBLC	Laurel Creek	Unmined

Analyses Planned

Multiple statistical evaluations are planned for the data. The primary analyses are:

1. Are there any differences among EIS classes for fish and for macroinvertebrates? EIS classes included in this evaluation are Unmined, Mined, Filled and Filled with Residences. The variables for these analyses are the West Virginia Stream Condition Index (SCI) for macroinvertebrates and a set of eight macroinvertebrate metrics included in the Region 3 report and the mid-Atlantic Index of Biotic Integrity (IBI) for fish and the nine component metrics for the IBI.

2. For the mainstem of Twentymile Creek, Twelvepole Creek and Kiah Creek: Is there a trend in the biological condition relative to the distance along the mainstem? The distance variable is a surrogate measure for additive mining and valley fill impacts. The response variables are the same analysis variables as number one above.

3. An examination of chemical and physical habitat factors that may contribute to any potential differences among EIS classes detected for fish and invertebrates. Chemical and physical habitat variables will be paired with fish and invertebrate metrics to look for significant correlations. Similar analyses will be conducted along the mainstem of Twentymile Creek, Twelvepole Creek and Kiah Creek.

Analyses Completed

EPA Region III Macroinvertebrate Data Results

Results of One-way Analysis of Variance (ANOVA) for the SCI and eight macroinvertebrate metrics are given in Tables 7 to 11. Sites were not consistently sampled across seasons due to drought conditions in the Summer and Fall of 1999. For this reason, analyses were done separately for each season. Least squares means with a Dunnett's adjustment was used to test for differences in EIS classes relative to a reference or unmined condition. Results are consistent across seasons. For the SCI and each metric across all seasons, except HBI in the Fall of 1999, significant differences among EIS classes were detected. In addition, multiple comparisons results indicated significant differences between unmined or reference condition and the filled sites, filled with residences or both for every metric, SCI and season combination (except HBI in the Fall of 1999).

Preliminary results of the analysis of the combined Region III and mining company data, support these conclusions.

Table 7: Region 3 Macroinvertebrate Data Results for Spring 1999

Total Number of Observations = 41
EIS Classes: Unmined, WV – MTM Reference, Mined, Filled, Filled & Residences
LS Means Comparisons: Unmined as comparative control

Response	ANOVA F-test p-value	Normality	Equal Variance	LS Means Results
SCI	<0.0001	Yes	Yes	F,F&R
Total Taxa	0.0199	Yes	Yes	F,F&R
EPT Taxa	0.0004	Yes	Yes	F,F&R
% EPT	<0.0001	Yes	Yes	F&R
HBI	<0.0001	Yes	Yes	F&R
% 2 Dominant	<0.0001	Yes	Yes	F,F&R
Mayfly Taxa	0.0003	Yes	Yes	F,F&R
% Mayflies	<0.0001	Yes	Yes	F,F&R
% Chironomidae	0.0003	Yes	Yes	F&R

Table 8: Region 3 Macroinvertebrate Data Results for Summer 1999

Total Number of Observations = 28
EIS Classes: WV – MTM Reference, Filled, Filled & Residence
LS Means Comparisons: WV – MTM Reference as comparative control

Response	ANOVA F-test p-value	Normality	Equal Variance	LS Means Results
SCI	<0.0001	Yes	Yes	F,F&R
Total Taxa	0.0016	Yes	Yes	F,F&R
EPT Taxa	<0.0001	Yes	Yes	F,F&R
% EPT	<0.0001	Yes	Yes	F,F&R
HBI	<0.0001	Yes	Yes	F,F&R
% 2 Dominant	0.0063	Yes	Yes	F,F&R
Mayfly Taxa	<0.0001	Yes	Yes	F,F&R
% Mayflies	<0.0001	Yes	No	F,F&R
% Chironomidae	0.0083	Yes	Yes	F&R

Table 9: Region 3 Macroinvertebrate Data Results for Fall 1999

Total Number of Observations = 27
EIS Classes: WV – MTM Reference, Filled, Filled & Residences
LS Means Comparisons: WV – MTM Reference as comparative control

Response	ANOVA F-test p-value	Normality	Equal Variance	LS Means Results
SCI	<0.0001	Yes	Yes	F,F&R
Total Taxa	0.0110	Yes	Yes	F
EPT Taxa	<0.0001	Yes	Yes	F,F&R
% EPT	0.0036	Yes	Yes	F&R
HBI	0.0257	Yes	Yes	None
% 2 Dominant	0.0204	Yes	Yes	F
Mayfly Taxa	<0.0001	Yes	Yes	F,F&R
% Mayflies	<0.0001	Yes	No	F,F&R
% Chironomidae	0.0123	Yes	Yes	F&R

Table 10: Region 3 Macroinvertebrate Data Results for Spring 2000

Total Number of Observations = 43
EIS Classes: Unmined, WV - MTM Reference, Mined, Filled, Filled & Residences
LS Means Comparisons: Unmined as comparative control

Response	ANOVA F-test p-value	Normality	Equal Variance	LS Means Results
SCI	<0.0001	Yes	No	F,F&R
Total Taxa	0.0040	No	Yes	F
EPT Taxa	0.0003	Yes	Yes	F,F&R
% EPT	<0.0001	Yes	No	F,F&R
HBI	<0.0001	Yes	No	F,F&R
% 2 Dominant	0.0002	Yes	Yes	F,F&R
Mayfly Taxa	<0.0001	Yes	Yes	F,F&R
% Mayflies	0.0003	Yes	Yes	F,F&R
% Chironomidae	<0.0001	Yes	Yes	F&R

Table 11: Region 3 Macroinvertebrate Data Results for Winter 2000

Total Number of Observations = 39
EIS Classes: Unmined, WV – MTM Reference, Mined, Filled, Filled & Residences
LS Means Comparisons: Unmined as comparative control

Response	ANOVA F-test p-value	Normality	Equal Variance	LS Means Results
SCI	<0.0001	Yes	Yes	F,F&R
Total Taxa	0.0131	Yes	Yes	F&R
EPT Taxa	0.0010	Yes	Yes	F&R
% EPT	<0.0001	Yes	Yes	F,F&R
HBI	<0.0001	Yes	Yes	F,F&R
% 2 Dominant	0.0002	Yes	Yes	F&R
Mayfly Taxa	<0.0001	Yes	No[#]	F,F&R
% Mayflies	<0.0001	Yes	Yes	F,F&R
% Chironomidae	<0.0001	Yes	Yes	F,F&R

The variability of the three mined sites is zero.

Combined Region 3/Penn State and Mining Company Fish Data

The combined fish data for Region 3/Penn State and mining companies were analyzed for differences among EIS classes. There was inconsistency in the number of seasons that sites were sampled and several sites were sampled in only one season. This limited the ability to complete a seasonal analysis for the fish data. For this reason, the IBI and component metric values for all sites sampled multiple times were averaged across season, and the mean value for a site was used in all subsequent analysis. The distributions of IBI scores in each of the EIS classes are shown in Figure 1. Distributions of the nine component metrics for the IBI are shown in Figures 2 to10. For comparison, the regional reference sites sampled by Penn State University (PSU) in Big Ugly Creek are also included in the plots. The data in Figure 1 indicates that the Filled and Mined classes have lower IBI scores overall than all other EIS classes. The Filled with Residences class had higher IBI scores than the Filled and the Mined classes. The Filled with Residences class and the Unimined class had similar median scores to the regional reference sites, although all EIS classes showed greater variability in IBI scores than the regional reference. Figure 1 shows that more than half of the Filled and Mined EIS classes scored “poor” according to the ratings developed by McCormick et al. (2001). Unmined and regional reference sites were primarily in the “fair” range.

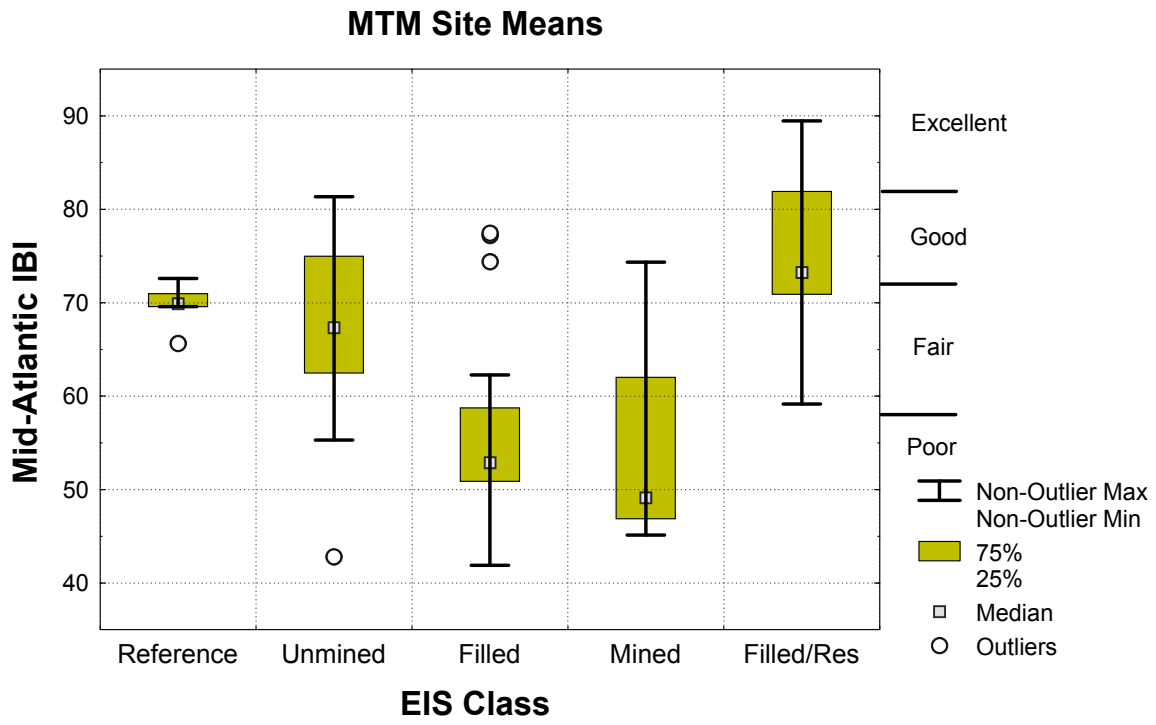

Figure 1. Box and whisker plot of mean IBI scores of sampling sites in 5 classes. Catchments less than 2 km^2 and samples less than 10 fish excluded. "Reference" are 5 regional reference sites in Big Ugly Creek, outside of study area. All other sites in MTM study watersheds. Assessment categories (McCormick et al.2001) shown on right side.

IBI scores were plotted , and did not deviate from expectations of normality. Because IBI scores were normally distributed, we used standard analysis of variance (ANOVA) to test differences among EIS classes, and Dunnett's test to compare each class to the Unmined (Control) class. Differences among the EIS classes were statistically significant (Table 12) by ANOVA, and the Dunnett's one-tailed test showed that the Filled IBI scores were significantly lower than the Unmined IBI scores (Table 13). Neither the Mined nor the Filled with Residences classes had significantly lower IBI scores than the Unmined class; in fact, the Filled with Residences class had higher IBI scores than the Unmined class (see Fig.1).

Table 12. Analysis of variance of IBI scores among EIS classes (Unmined, Filled, Mined, and Filled/Residential)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2335.56	778.52	6.70	0.0009
Error	40	4651.31	116.28		
Corrected Total	43	6986.87			

R-Square	Coeff Var	Root MSE	INDEX Mean
0.334	17.022	10.783	63.35

Table 13. Dunnett's test comparing IBI values of EIS classes to the Unmined class. Comparisons significant at 0.05 are indicated by *

Alpha	0.05
Error Degrees of Freedom	40
Error Mean Square	116.28
Critical Value of Dunnett's t	2.15

EIS_CLAS Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
Filled/R - Unmined	7.919	-Infinity	17.833	
Filled - Unmined	-9.860	-Infinity	-1.485	***
Mined - Unmined	-12.227	-Infinity	0.930	

The individual metrics that comprise the IBI are not uniform in their response to stressors (McCormick et al. 2001): some may respond to habitat degradation, some may respond to organic pollution, and some may respond to toxic chemical contamination. Of the nine metrics in the IBI, two were statistically significantly different among the EIS classes: the number of minnow species and the number of benthic invertivore species (Figures 2 and 4). On average, Filled sites were missing one species of each of these two groups compared to Unmined sites. The third taxa richness metric, Number of Intolerant Species, was not different between Filled and Unmined sites (Figure 7). Two additional metrics, Percent Predators and Percent Tolerant Individuals, showed increased degradation in Filled sites compared to Unmined sites, on average, but the difference was not statistically significant (Figures 6 and 10). Four metrics in the data set were dominated by zero values: Percent Sculpins, Percent Gravel Spawners, Percent Non-native Fish, and Percent Large Omnivores (Figures 3, 5, 8 and 9). Because of the zero values and the resultant non-normal distribution, parametric hypothesis tests (e.g., ANOVA) are problematic.

Figure 2: Number of Invertivore Species

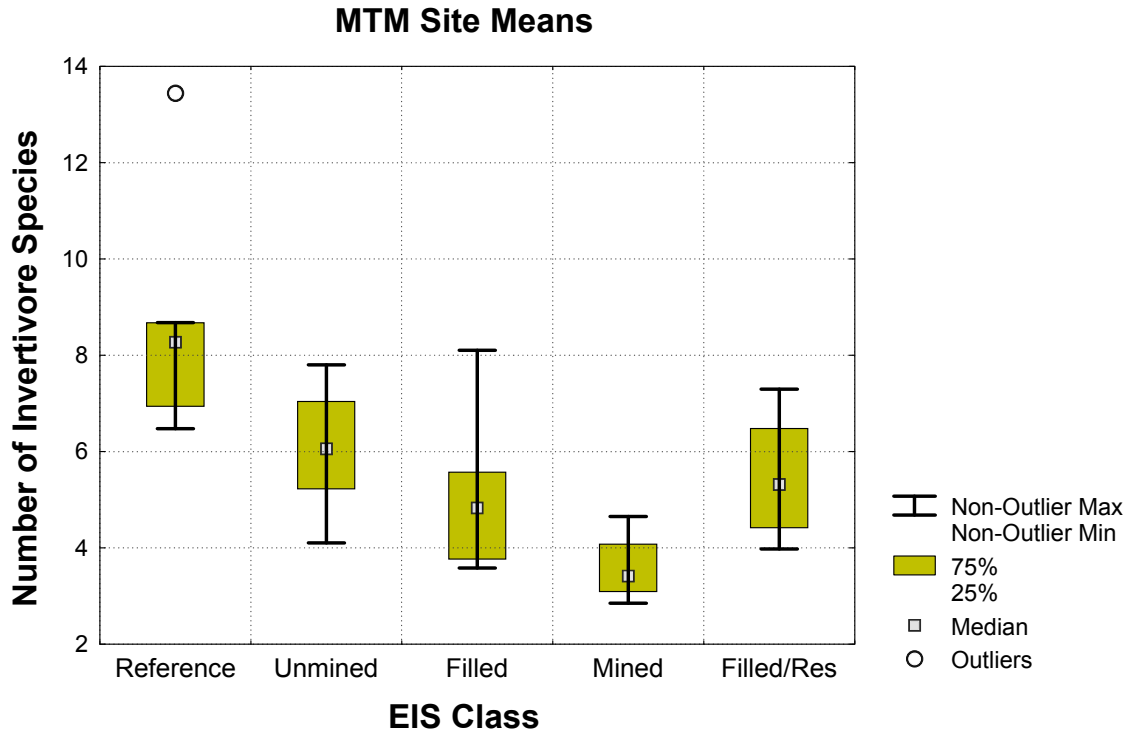

Figure 3: Percent Sculpins

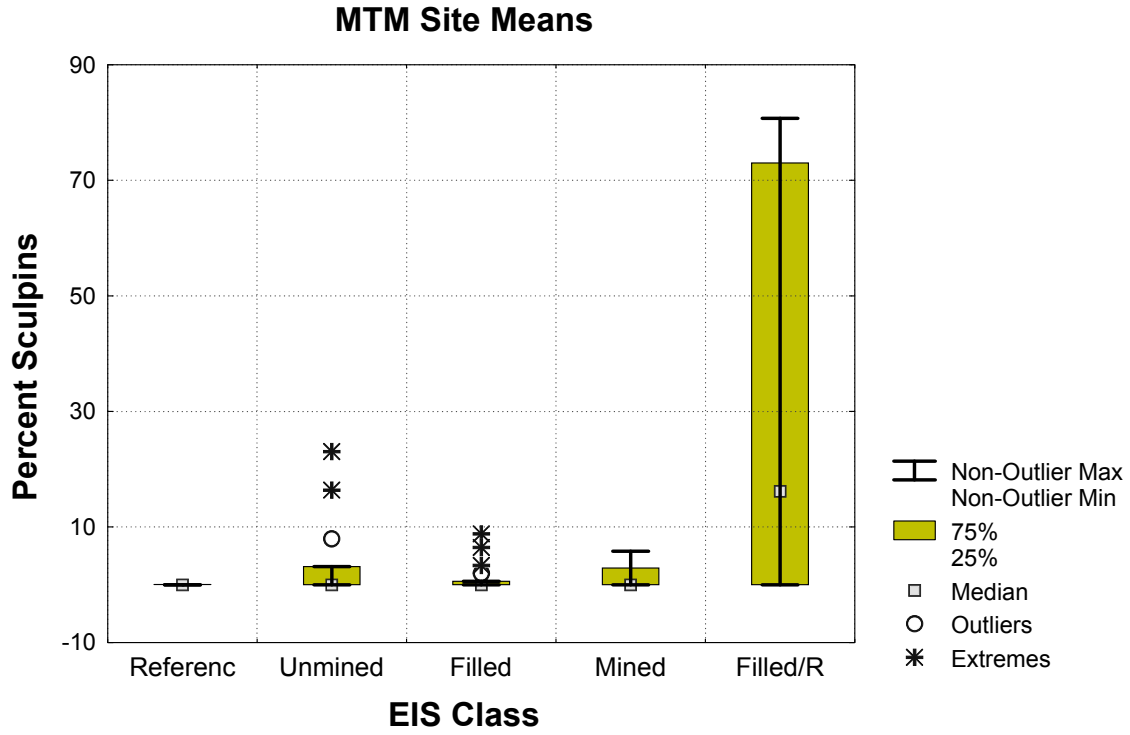

Figure 4: Number of Minnow Species

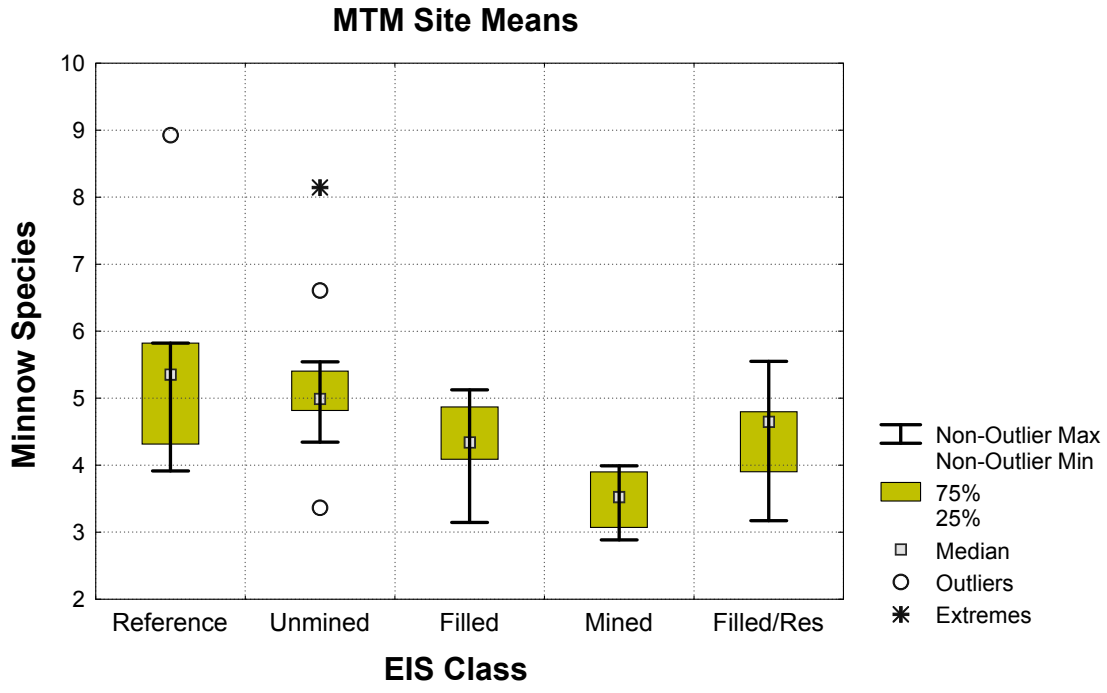

Figure 5: Percent of individuals that are gravel spawners

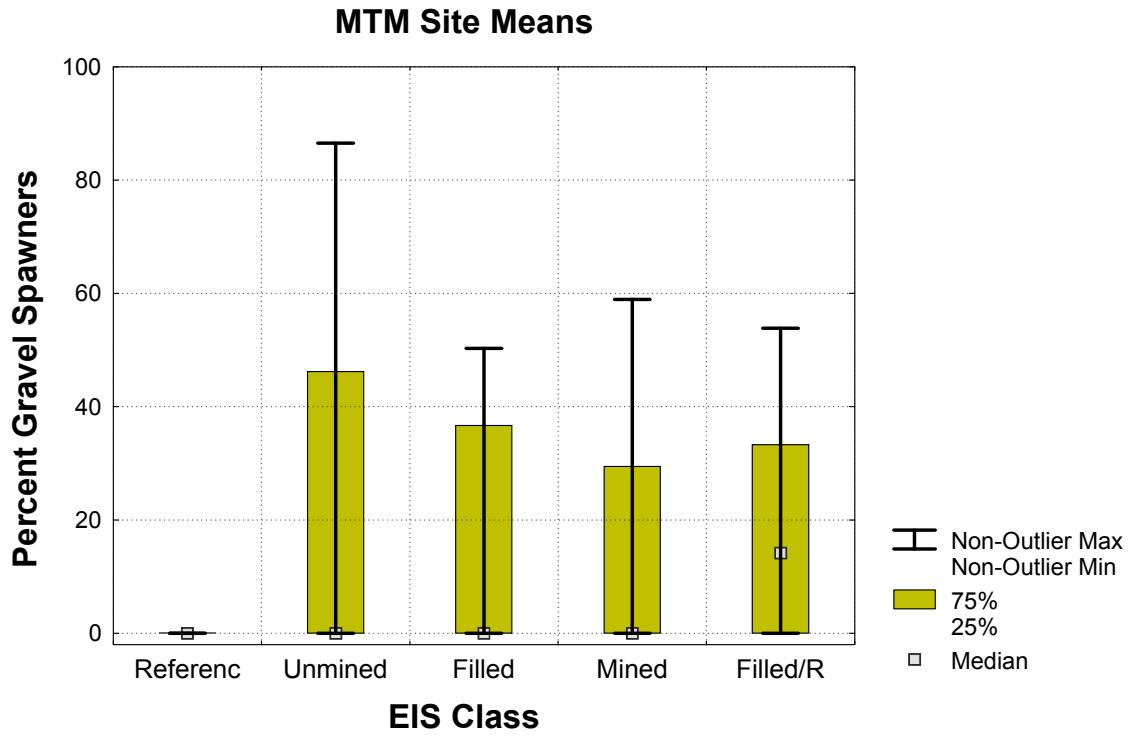

Figure 6: Percent Predators

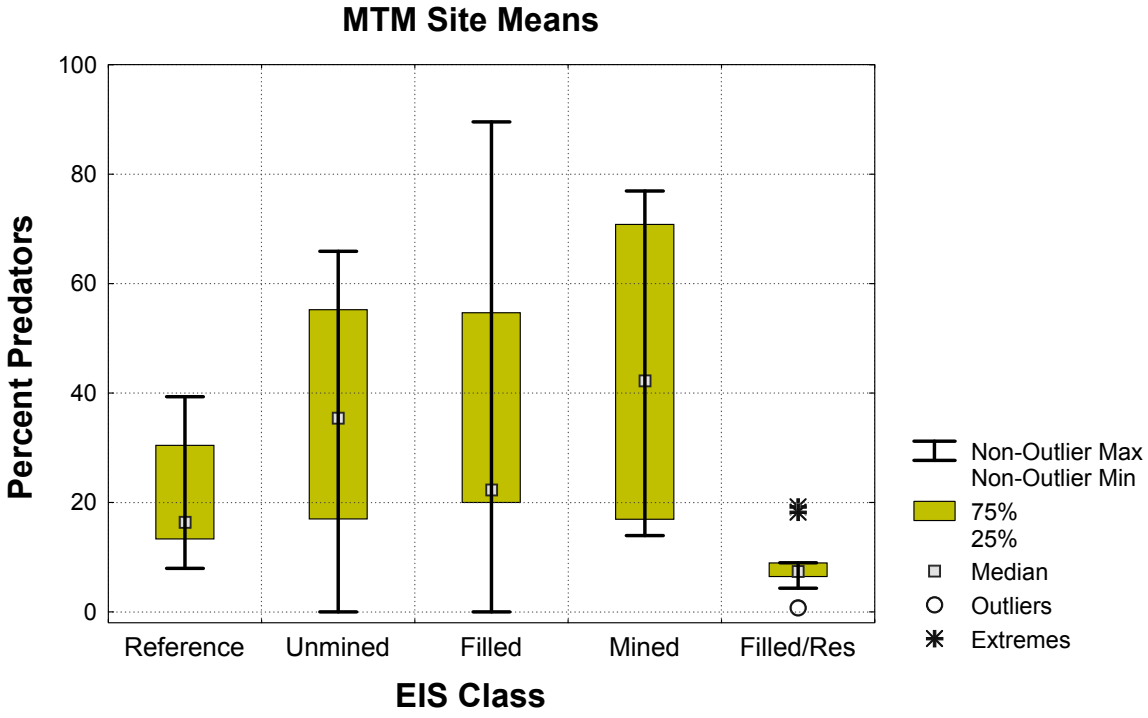

Figure 7: Number of Intolerant Species

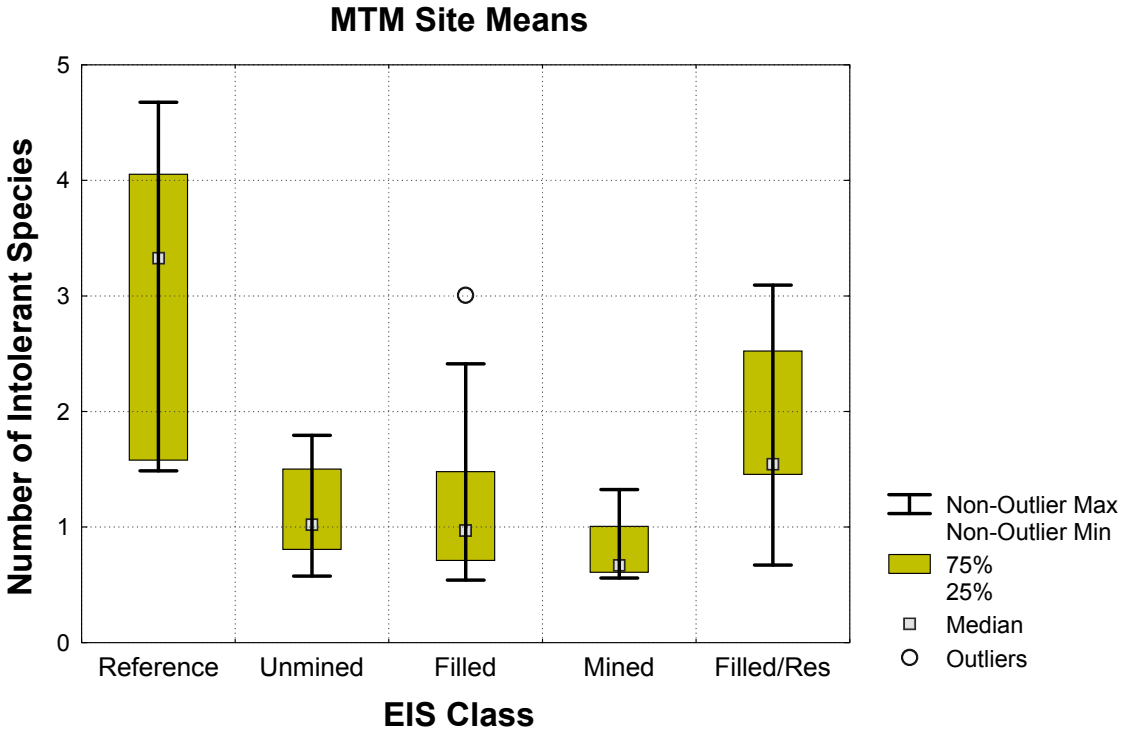

Figure 8: Percent of Fish that are not native

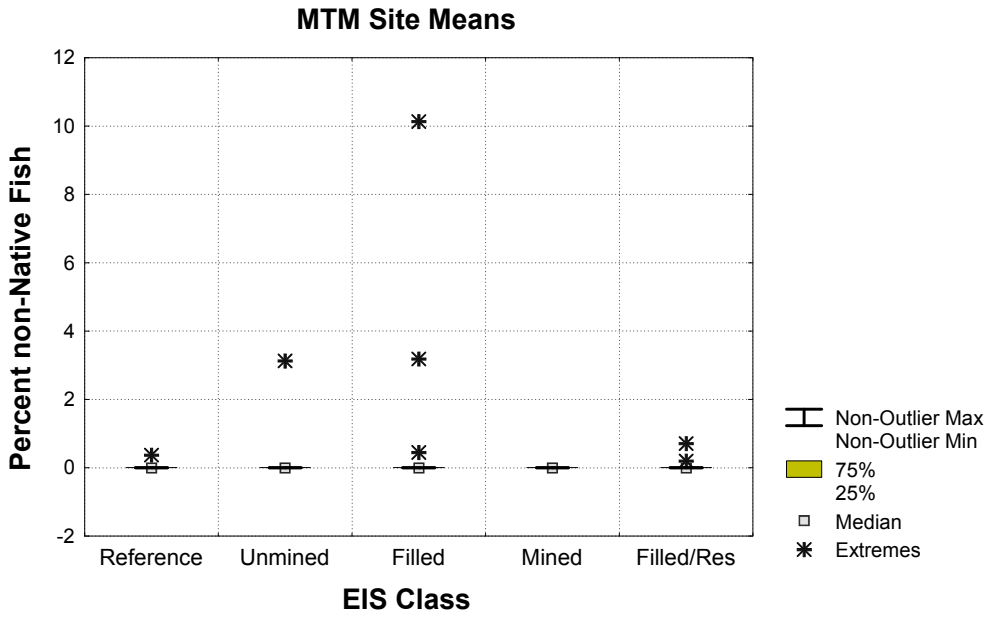

Figure 9: Percent of individuals that are large omnivores

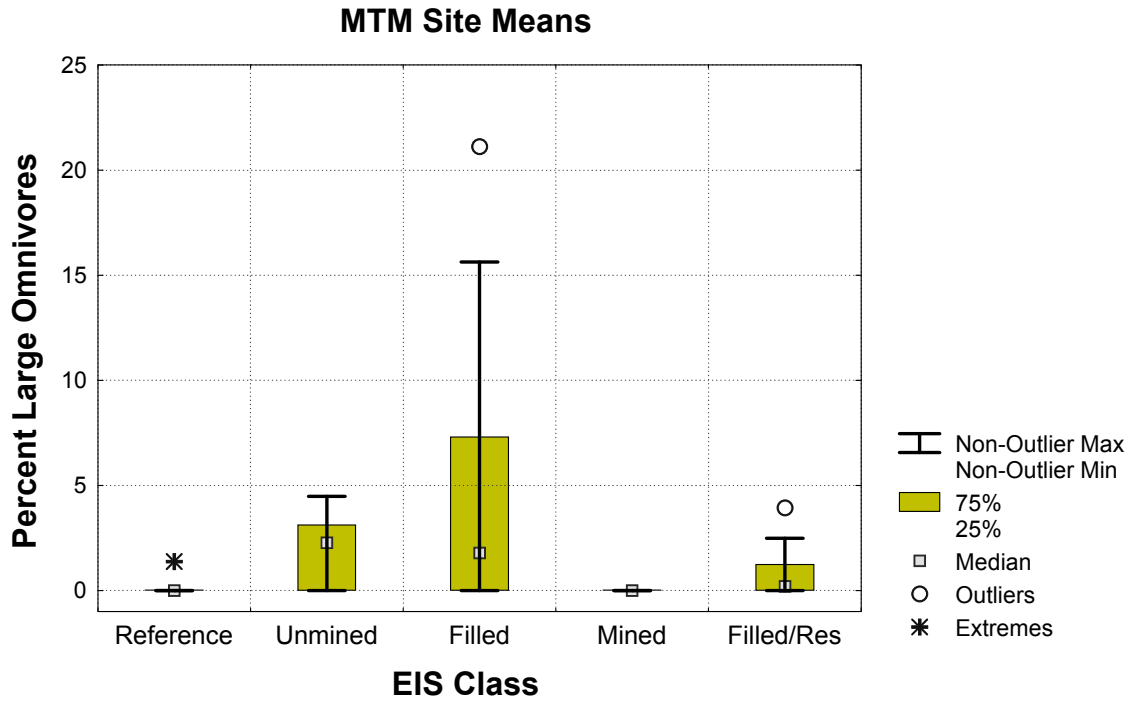

Figure 10: Percent of individuals that are tolerant